MUID noisy events rejection
status update : January 18, 2013

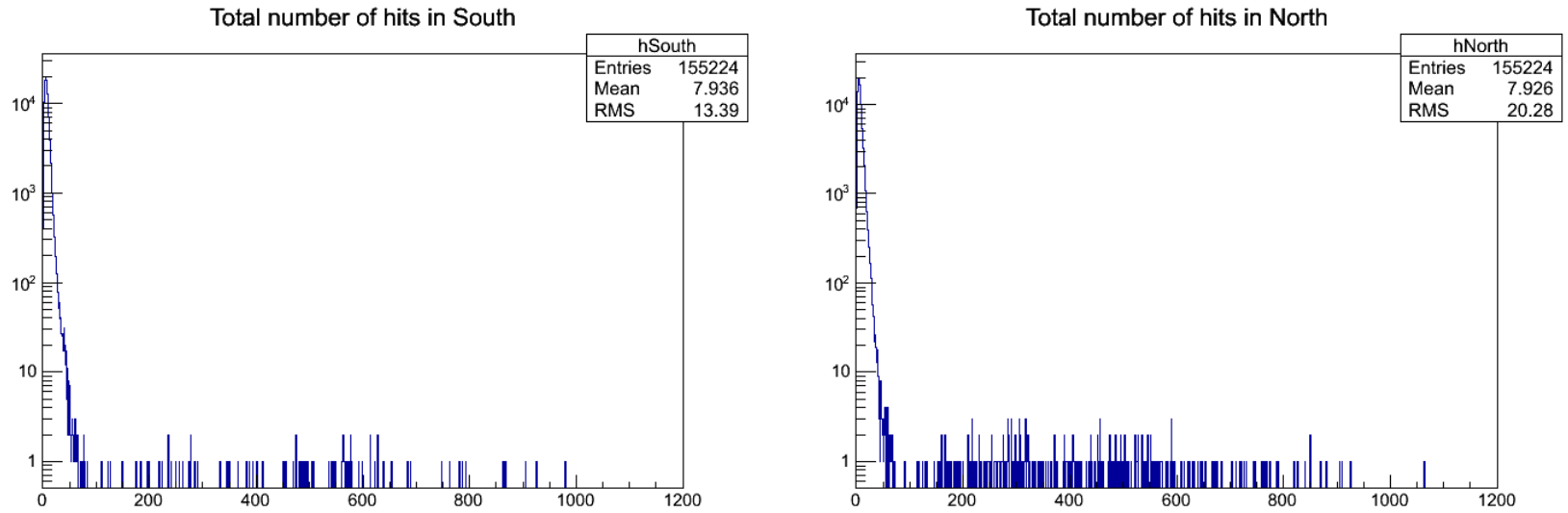
A fraction of events show very large activities in MUID, and could be caused by either electronics noise (ringing) and/or large beam backgrounds. These events slow down the production/reconstruction, due to many false road candidates as input for MUTR etc. The events would need to be rejected for any physics analysis involving the muon arms. (The MUIDLL1 trigger has a rejection for these sort for events, but for users of other triggers, the noisy events have to be rejected.)

The runs that have been looked at so far are:

1. pp: runs 365723 and 368790. The plots below are from run 365723 - a segment that was on Achim's list of long/problematic production jobs.
2. Au+Au: only checked in online mon. so far - need to study test segment/file. Should have less hits than central U+U though.
3. U+U: Plots below are from run 372006.

Total number of hits per event - pp

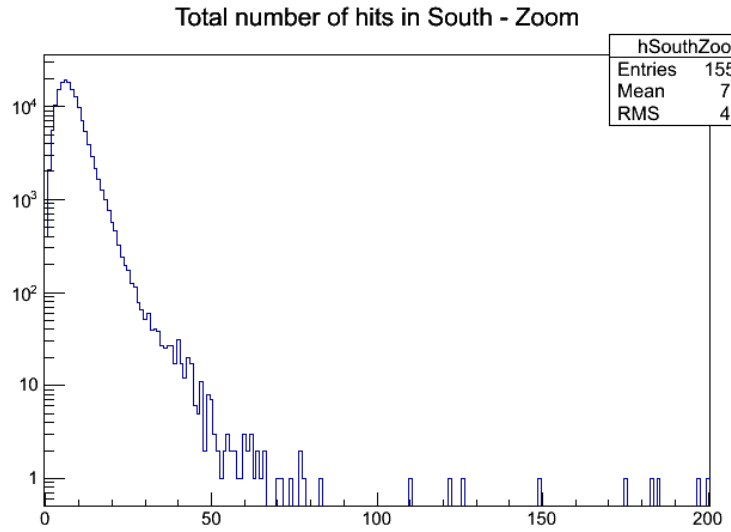
First we look at the total number of hits per event. Note the y-axis log scale. A few hundred of the total approx. 155k events in the studied file have an unphysically large number of hits.

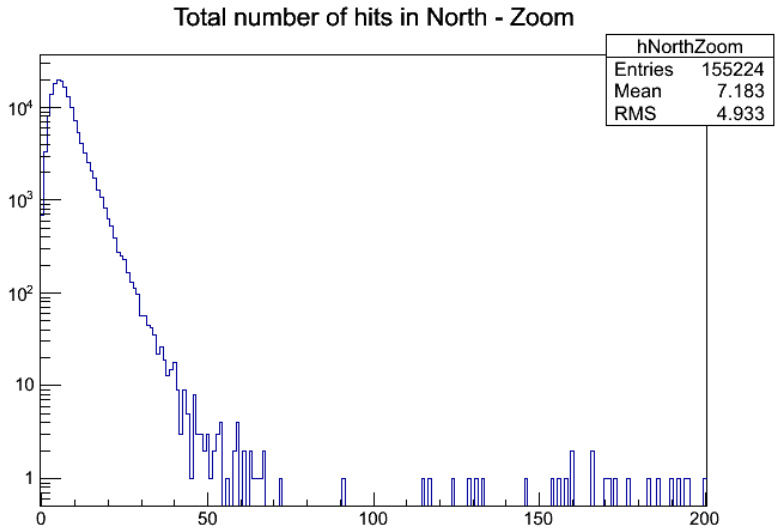


[South left, North right]

Total number of hits per event - pp : Zoom 3

Same plots as on the previous slide, but now zoomed in on the x-axis. I think these plots clearly illustrate that a safe cut for pp to separate physics events from the "grass" of ringing/noise events, would be about 100 hits/event maximum in any arm. (80 or so might also be OK but 100 should be safe)

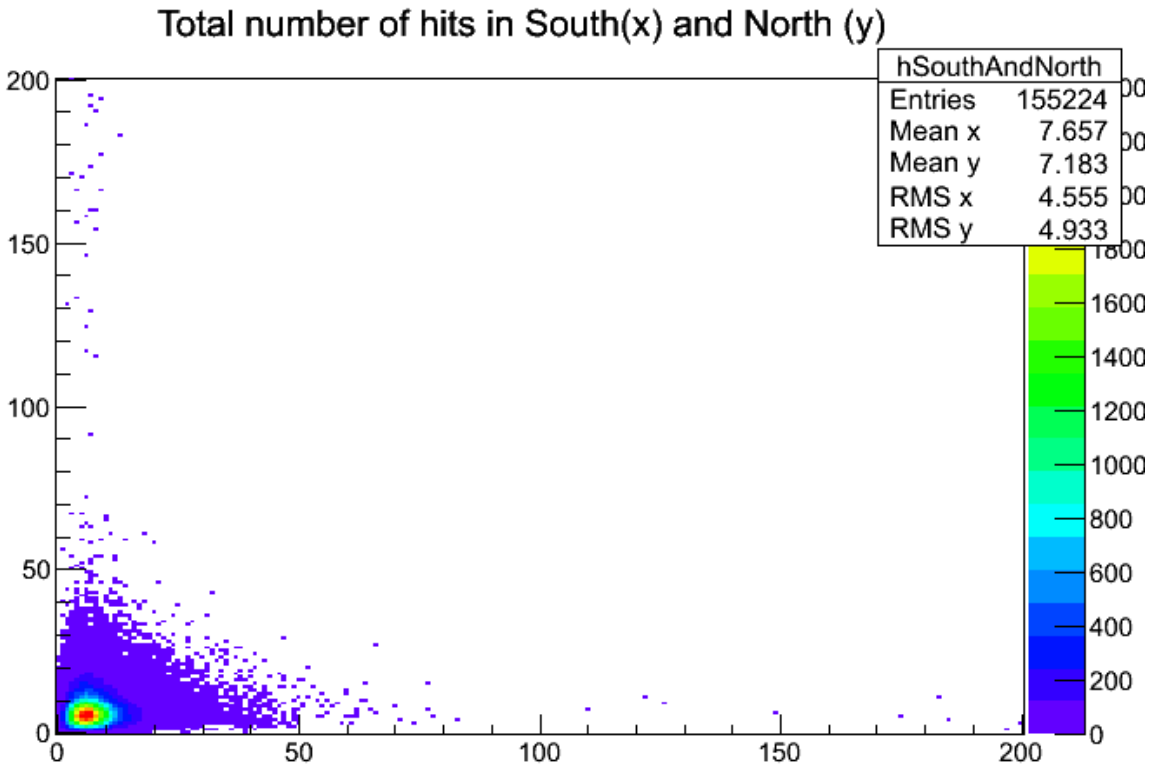




[South left, North right]

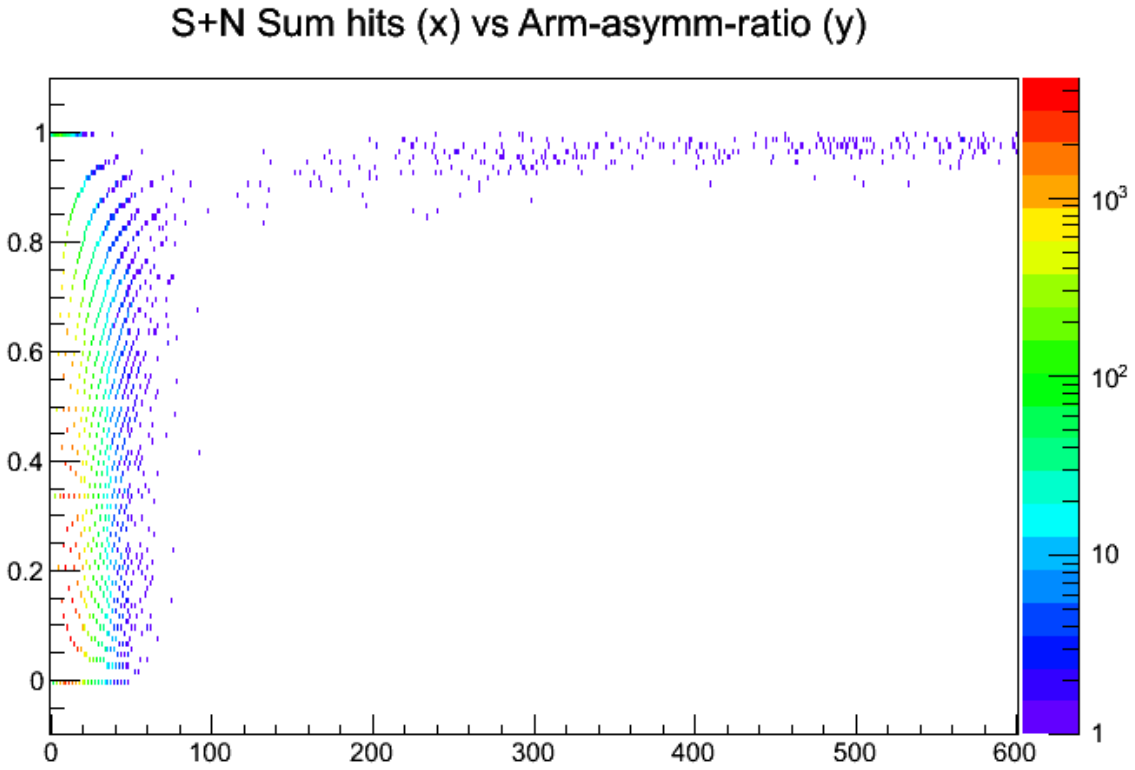
Total number of hits per event - pp : 2D

Another way of looking at the distribution of hits is with one arm vs the other. In the plot below, the number of hits in North (y-axis) vs South(x-axis) is shown. One can see that in the cases with very large number of hits in one arm, there are few hits in the other, which is consistent with what is expected for noise.



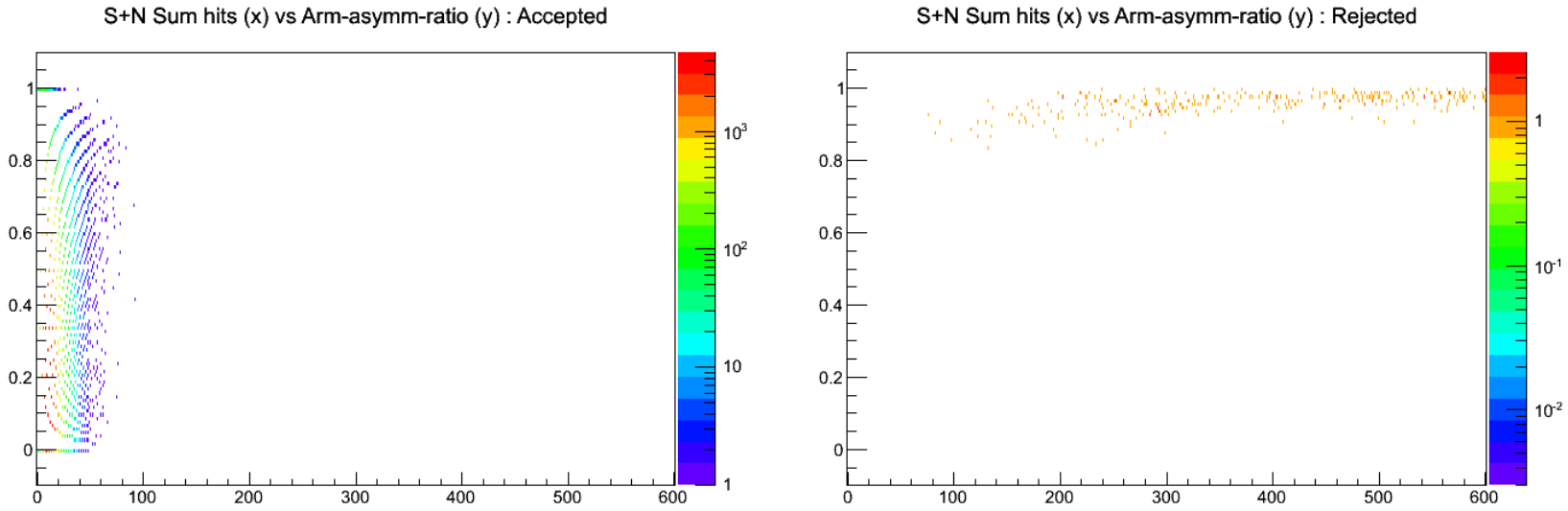
Total number of hits per event - pp : Asymmetry ratio 5

One way to quantify the difference between the two arms is to plot the difference between them, divided by the sum, i.e. $(max - min)/(max + min)$. In the plot below, this ratio (y-axis) vs the sum value is shown. One can again see that as the number of hits increase, so does the asymmetry.



Total number of hits per event - pp : Asymmetry cut 6

Vince made a good suggestion for a first principle cut for the asymmetry ratio, which changes with the sqrt of the total number of hits, i.e. $(max - min)/(max + min) > Z/\sqrt{max + min}$ would be rejected. For the plots below $Z = 8$ is used, and seems to do a reasonable job.

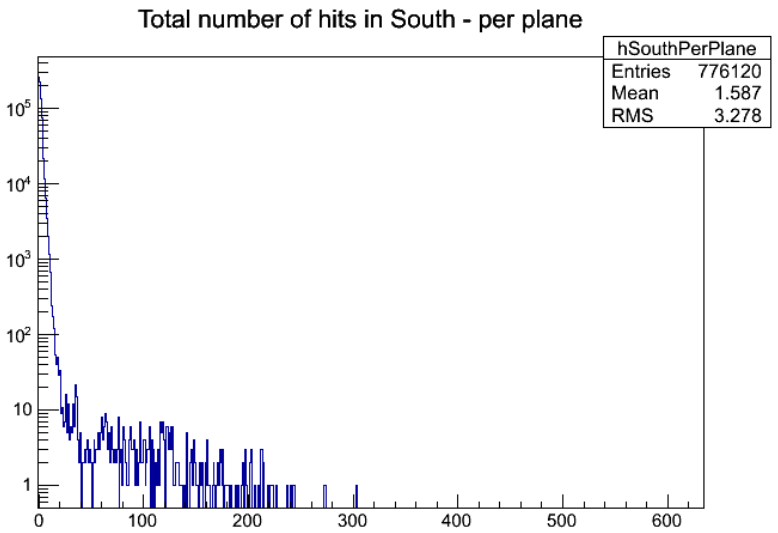


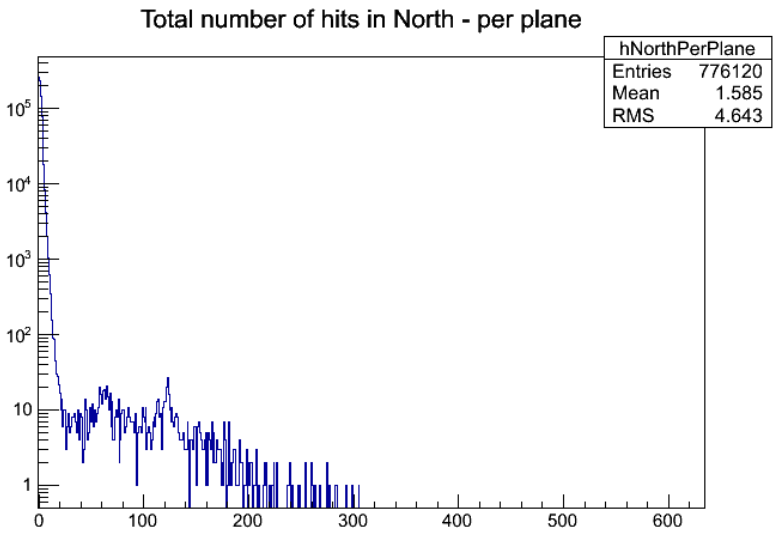
[Accept left, Reject right]

Total number of hits per event - pp : per plane 7

Same plots as on the previous slides, but now we look at the number of hits per plane, i.e. 5 times as many histogram fills as events (since we have 5 planes per arm).

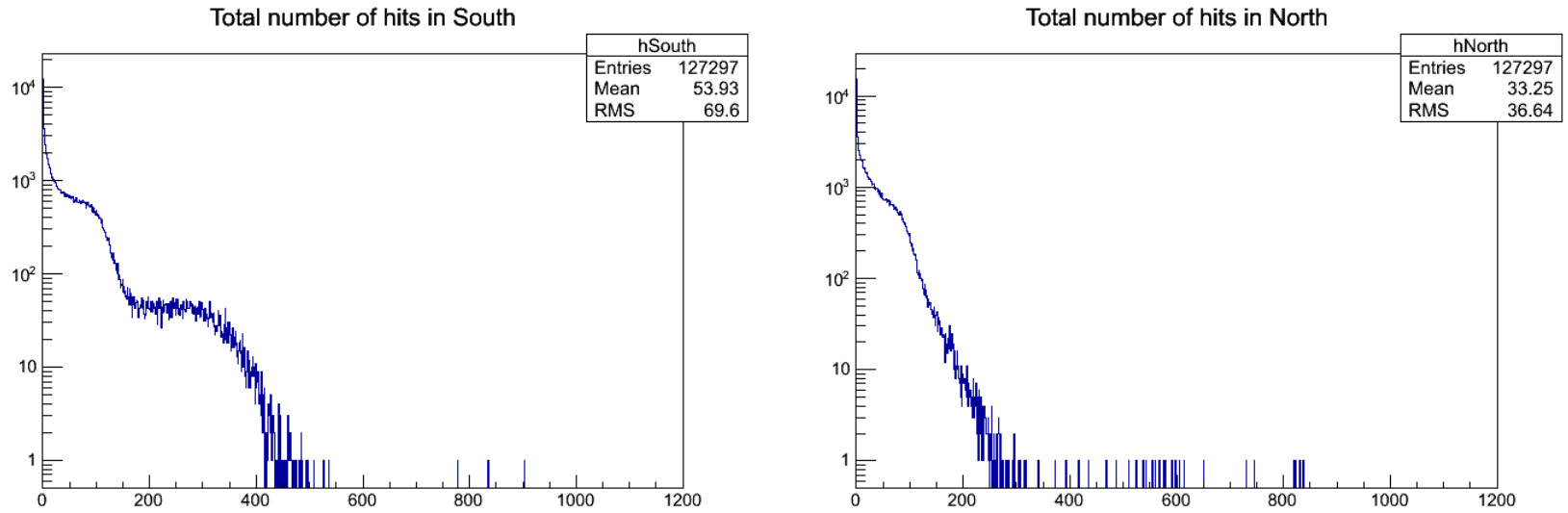
The current offline cut (in MuiooReco) is to cut away any event where there were more than 300 *clusters* in any plane. Note that the plot below is for *hits* and not *clusters*. The definition of a MUID cluster (with the default ISOLATED clustering mode) is one or two adjacent hits. With a total number of 326 horizontal and 308 vertical possible hits per plane, the maximum number of hits in a plane is 634 and I believe the maximum number of clusters is thus (every other one fired) 317. So, we should expect a maximum cluster cut of 300 in a plane to not cut away many events at all. There is in addition however also a cut in the roadfinder: it will skip any arm with more than 300 hits (and prints a message when doing so).





Total number of hits per event - UU

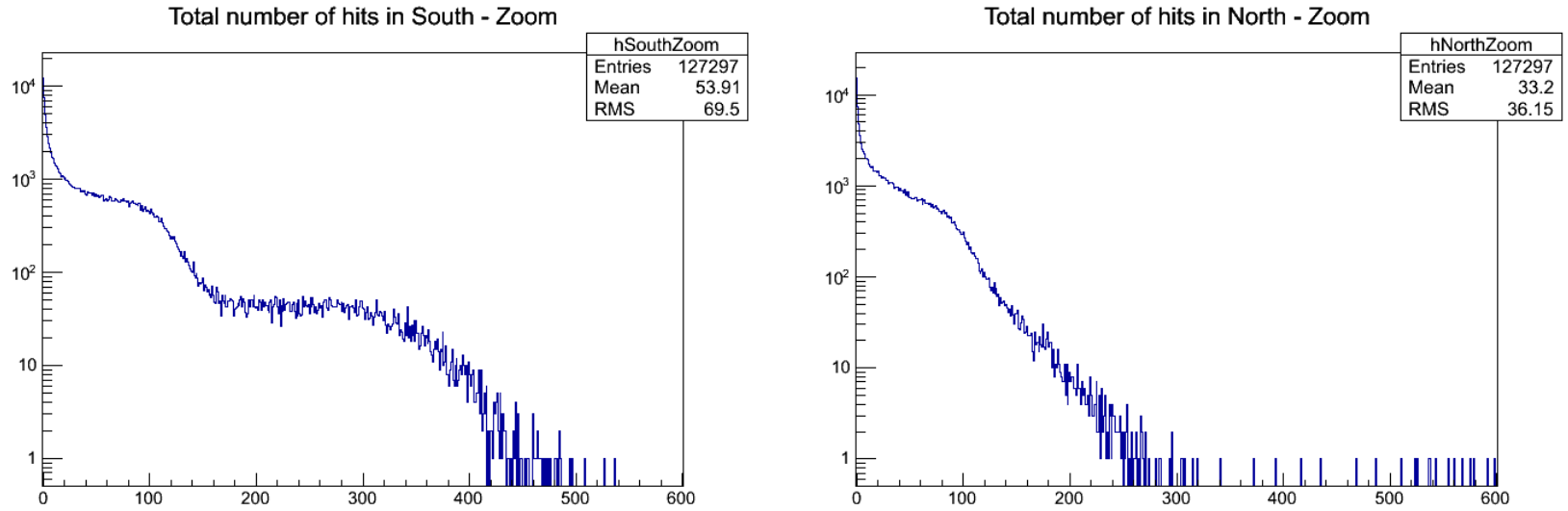
Next: let us look at data from $U + U$. As before, first we look at the total number of hits per event. Note the y-axis log scale. You can see that the amount of hits per event go out further than for pp: up to about 300 hits per arm for the North arm. Note though the significant bump and extended tail for the South arm.



[South left, North right]

Total number of hits per event - UU : Zoom

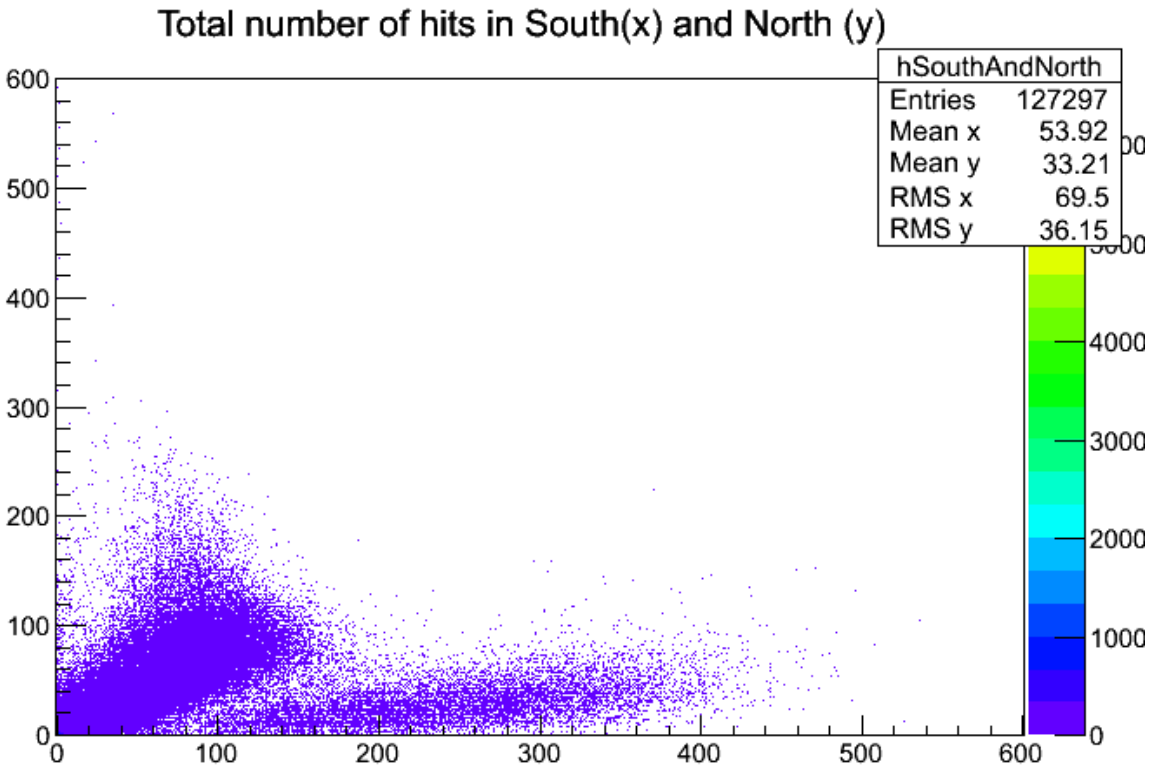
Same plots as on the previous slide, but now somewhat zoomed in on the x-axis.



[South left, North right]

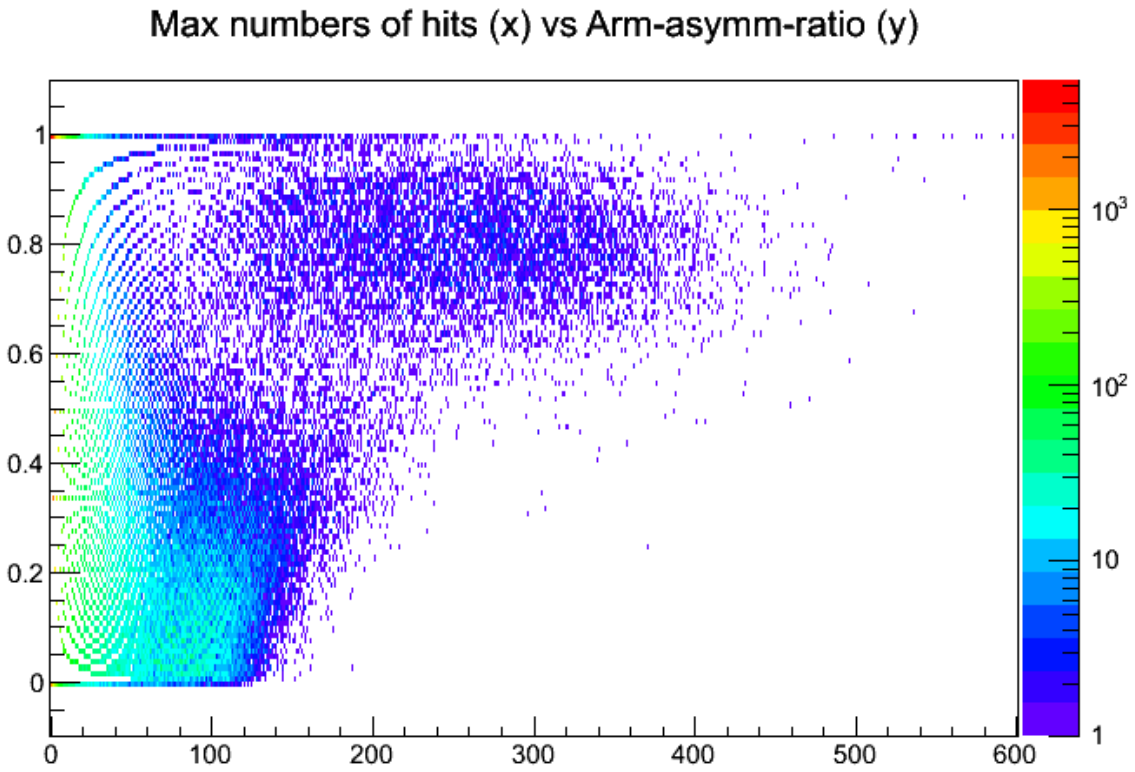
Total number of hits per event - UU : 2D

In the plot below, the number of hits in North (y-axis) vs South(x-axis) is shown. One can see that besides the normal wide-correlation of hits in the two arms, there is an extra band, with more hits in the South (x) than in the North (y) arm.



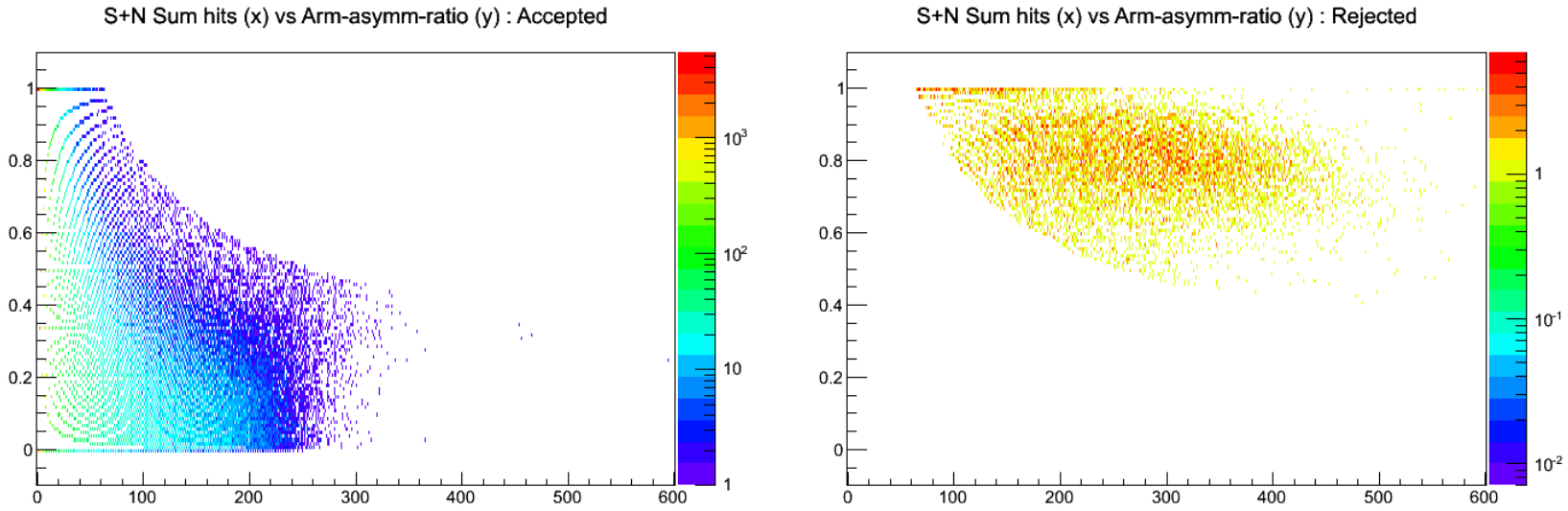
Total number of hits per event - UU : Asymmetry ratio 11

Another way of quantifying the difference between the two arms is to plot the difference between them, divided by the sum, i.e. $(max - min)/(max + min)$. In the plot below, this ratio (y-axis) vs the max value(x-axis, arm with most hits) is shown. One can again see that as the number of hits increase, so does the asymmetry.



Total number of hits per event - UU : Asymmetry cut 12

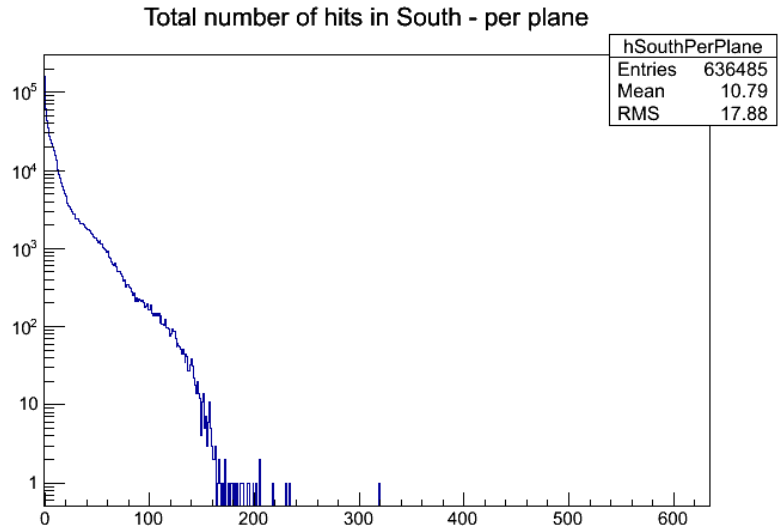
Here we use the same asymmetry cut as for pp i.e. $(max - min)/(max + min) > Z/\sqrt{max + min}$ would be rejected. For the plots below $Z = 8$ is used, and seems to do a reasonable job.

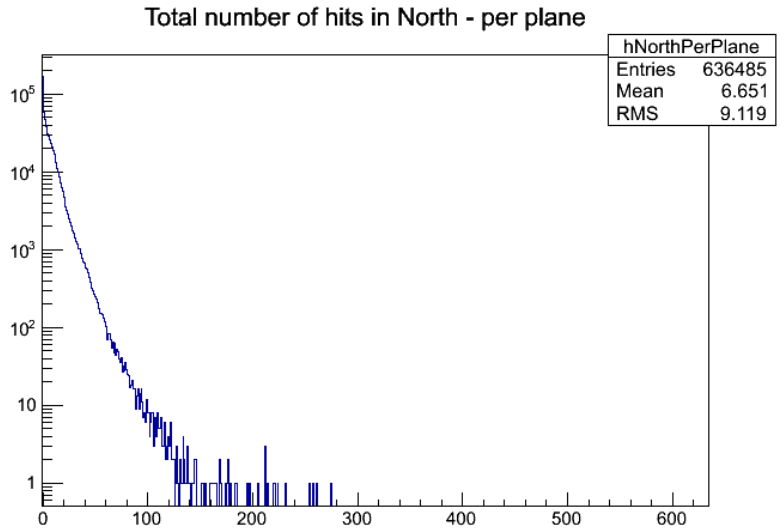


[Accept left, Reject right]

Total number of hits per event - UU : per plane (gap) 13

As for pp, let us also look at the number of hits per plane. i.e. 5 times as many histogram fills as events (since we have 5 planes (gaps) per arm).
Note that only approx. one event (for the South arm) in the studied PRDF file would potentially be removed by the offline > 300 clusters or hits/event cut.

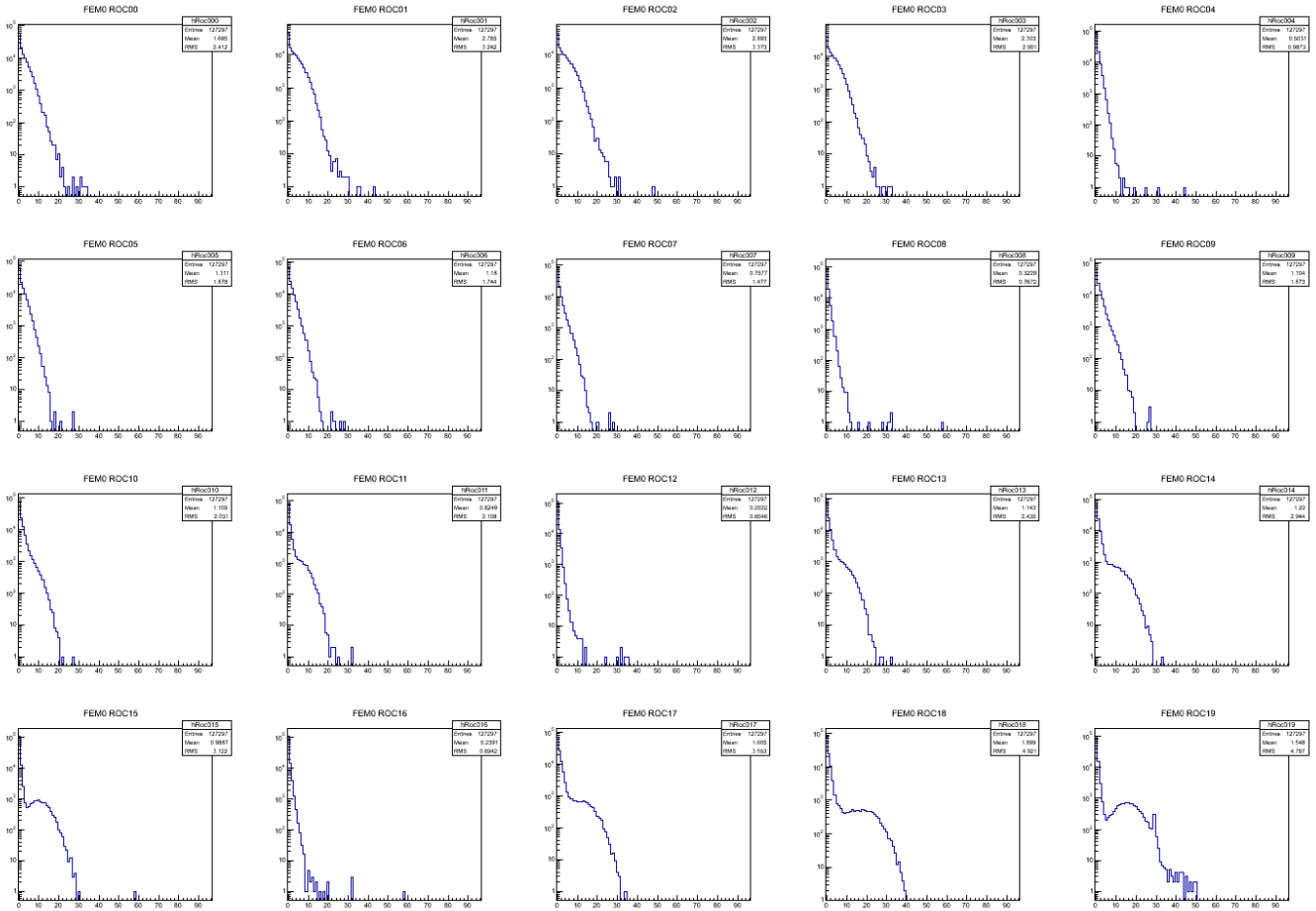




[South left, North right]

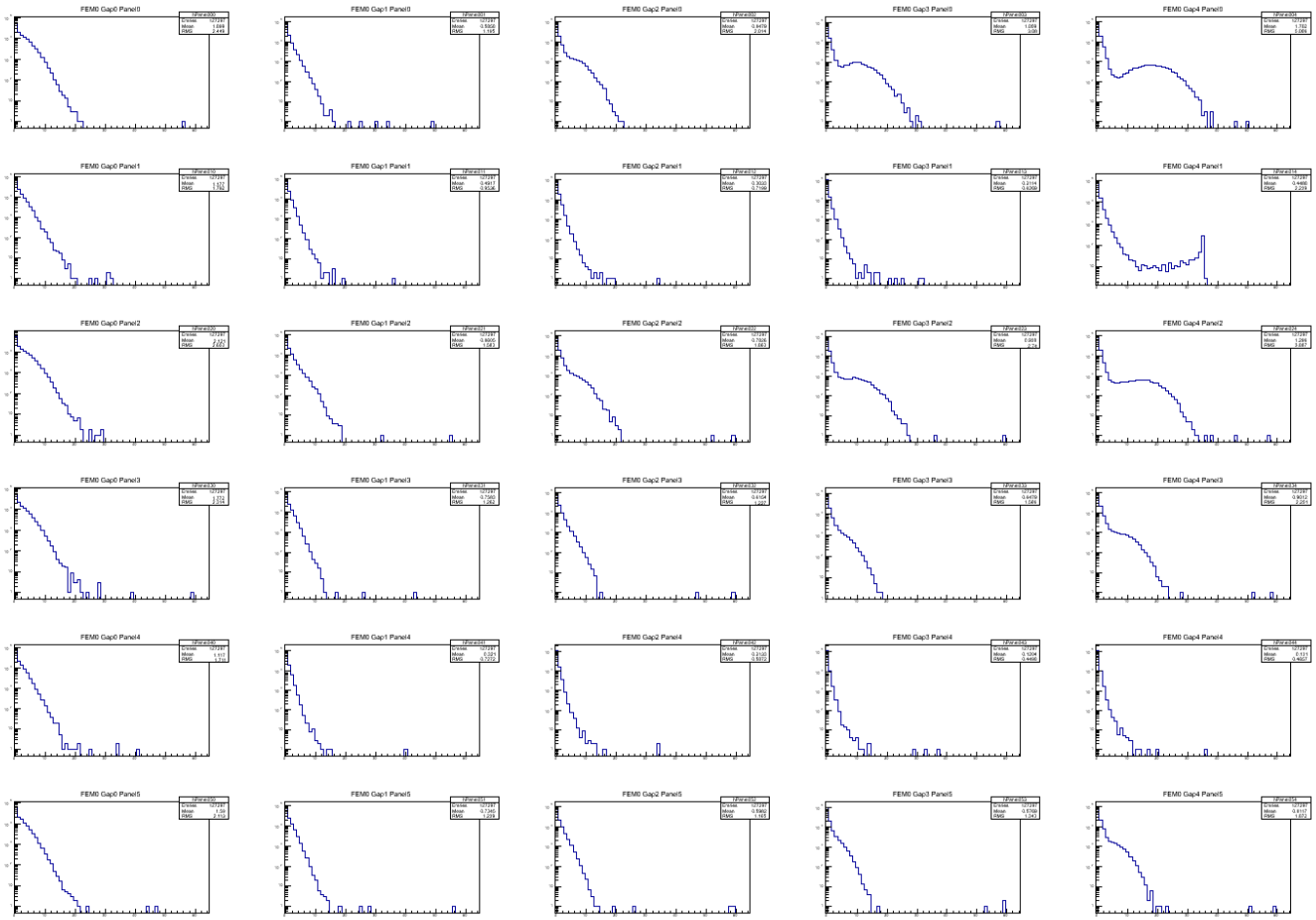
Nhits per event - UU : per ROC, South Horiz

To further investigate where the extra MUID hits may be coming from, we can also see if the number of hits correlate with some particular ReadOut Cards; there are 20 of those in each orientation. The plot below is for South Horizontal FEM (1/4th of full MUID). One can see bumps in the distribtions for the later ROCs (corresponding to later gaps).



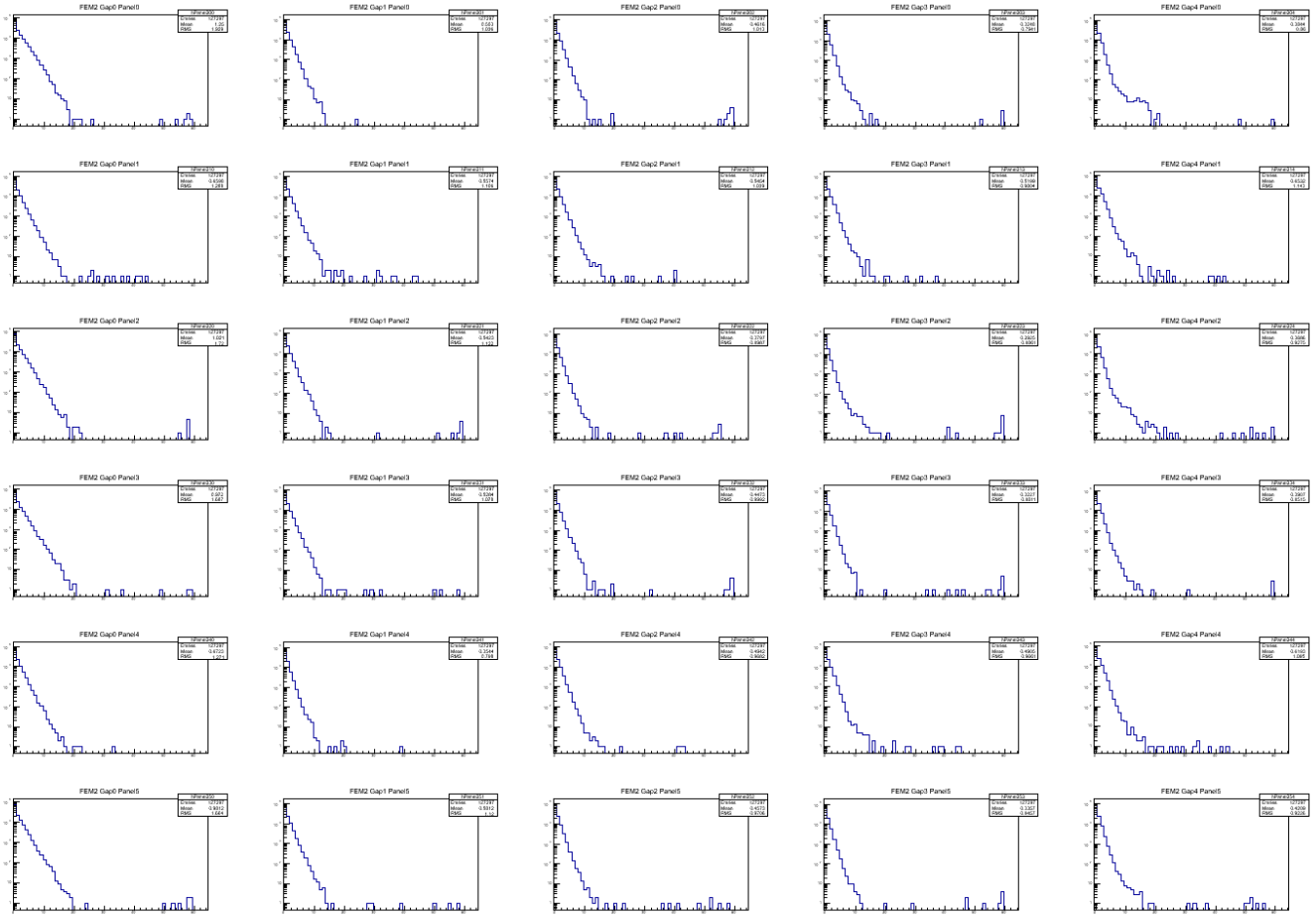
Nhits per event - UU : per Panels, South Horiz

We can also see if the number of hits correlate with some particular detector panels; there are 20 of those in each orientation. The plot below is for South Horizontal FEM (1/4th of full MUID), with the 5 columns from left to right corresponding to the MUID gaps, and the 6 rows of plots corresponding to the panels (0 at the top). One can see a background bump in the last gaps, perhaps in particular for panels 0-2 (upper panels).



Nhits per event - UU : per Panels, North Horiz

Same plot as on previous slide, but now for North Horizontal FEM (1/4th of full MUID). The pattern seen for the South (background bump in the last gaps) is not really observed in the North arm.



Summary

- We would like to cut away more of the noisy events than the (loose) rejection cut that is in the offline code can be expected to do.
- It is maybe most straight-forward to make a rejection cut based on the number of hits rather than clusters, as done in the MUID roadfinder.
- Not that trivial to make a simple cut that works for all species (from pp to $U+U$).
- Safe to cut away events with large beam backgrounds in one or the other arms? I.e. safe to remove events with very large asymmetries or differences between the arms? [Say for instance if one arm has at least 100 hits, and the other arm has less than 10 hits (i.e. at least a factor 10 asymmetry between the two arms) - is it safe to throw away the event as being likely background/unphysical?]
- My favorite suggestion (thanks Vince) is for a two step cut:
  a) $if(nHitsSouth > X||nHitsNorth > X)skipEvent()$;
  b) $max = max(nHitsSouth, nHitsNorth)$;
  $r = (max-min)/(max+min)$; $if((max+min) > Y \&\& r > Z/sqrt(max+min))skipEvent()$;
  If people agree with this approach, I can suggest values for the cut parameters X,Y,Z. Default values (X=300 used on the MUID roadfinder) from the plots shown above would be Z=8.0, $Y=Z^2$.